AN ANALYSIS OF VEGETATION ON STRANDED COASTAL DUNE RANGES BETWEEN ROBE AND NARACOORTE, SOUTH AUSTRALIA

by R. M. E. WELBOURN and R. T. LANGE

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SUMMARY

The presence or absence of 80 species has been scored in 330 samples of sclerophyll forest on nine dune ranges, and the data classified by association-analysis.

The vegetation is a mosaic of groups, within which four main groups may be distinguished. These roughly correspond to orthodox vegetation societies, but key species are determined solely by measured association with other species, without reference to physical prominence. For example, the species with the highest degree of association in this study, *Phyllota pleurandroides*, is a small shrub.

The potential value of the groups in vegetation mapping is indicated.

INTRODUCTION

The purpose of this study was to show by measurement, the floristic composition of the dune range vegetation and to discuss factors controlling its disposition. A discussion of analytical methods used has been published elsewhere (Welbourn and Lange, 1967). The study was an M.Sc. project with the University of Adelaide, to whom, with the State Herbarium of South Australia, grateful acknowledgment is made.

The habitats are distinct ranges considered to be successively younger toward the present coast. In the area studied there are at least twelve ranges subparallel to the coast, about 2 km wide by 30 m high above the otherwise flat countryside (Pl. 1). Each range consists of two portions. The core is more or less consolidated calcareous beach sand, a relic of coastal dunes formed at various stages of the Pleistocene from about 600 to 200 thousand years B.P. (Sprigg, 1952). This material outcrops westward as aeolianite limestone, parent material of the terra rossa soil carrying open woodland. Overlying this core are siliceous sands, of uncertain origin but considered to be windsorted, leached and of Recent age (Blackburn *et al.*, 1965). These sands form the bulk of each range, and are the parent material of the podsol which supports the predominant vegetation. This is largely the *Eucalyptus baxteri* association within the dry sclerophyll forest formation (Crocker, 1944).

Pattern, the degree of non-randomness in the spatial distribution of individuals, was the vegetation feature investigated. Since pattern reflects habitat variation, the patterns of ecologically similar species tend to coincide, or associate, thus indicating a vegetation group. The variable commonly measured to reveal such groups is species frequency, the proportion of sample quadrats occupied. Associations were determined with such data in this study.

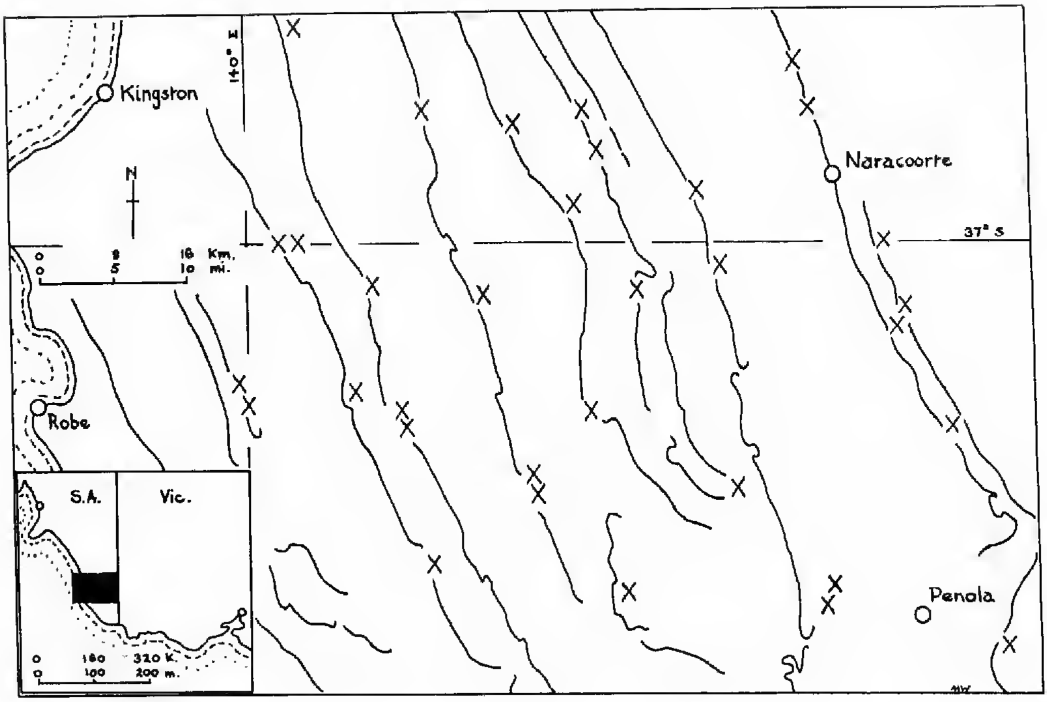
Kingston
140° E
N
0 8 16 Km.
0 5 10 mi.
Naracoorte
37° S
Robe
S.A.
Vic.
0 160 320 K.
0 100 200 m.
Penola

Fig. 1.

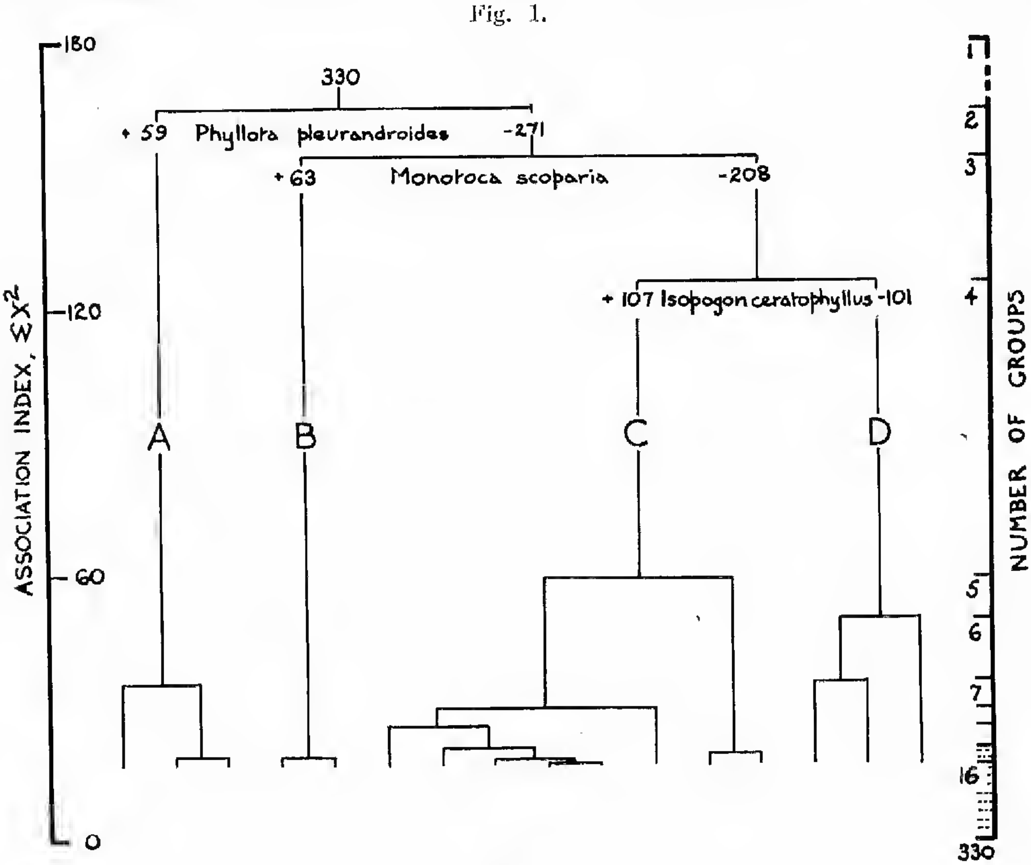
180
120
60
0
ASSOCIATION INDEX, ΣX²
330
+ 59 Phyllota pleurandroides -271
+ 63 Monotoca scoparia -208
+ 107 Isopogon ceratophyllus -101
A
B
C
D
NUMBER OF GROUPS
2
3
4
5
6
7
16
330

Fig. 2.

METHODS

The area bounded by Kingston, Naracoorte, Penola and Robe was selected for study because the dune ranges are most distinct here (Fig. 1). Sampling areas were located within the remaining estimated 750 sq. km of vegetation so that the variation of mean annual rainfall, about 200 mm, would be represented on each range. Most of the vegetation was unnatural in some way, so that, having excluded areas obviously disturbed, or burnt less than four years before, or dominated by bracken, 33 areas remained. At each of these, ten 20 sq. m circular samples were located randomly where feasible, otherwise systematically. All species likely to occur in upland sites in the area studied were scored; also *Banksia marginata* and *Calytrix tetragona* were divided into *ad hoc* forms to render the data more sensitive to habitat variation. A reference collection of relevant species was used throughout.

The method selected to reveal vegetation groups was association-analysis as proposed by Williams and Lambert (1959). Their recommended association index is for each species the sum of all the *chi-squared* values obtained from contingency testing with each other species in turn. The procedure is to subdivide the 330 samples firstly into two groups, respectively with and without the appropriate key species. The key species is that with the highest association index at any stage of subdivision. Within each of the groups thus formed, the process is repeated, fractionating the original single group of 330 samples into progressively more subdivisions. In this study, only species with a frequency greater than 1% were considered; data were computed electronically, and subdivision was stopped at 16 groups.

THE VEGETATION

The analysis in these terms reveals a series of groups of decreasing importance, conveniently represented as a hierarchy (Fig. 2). The validity of any group as a recognizable vegetation community is indicated by the range of association index over which it persists undivided; this is supported by its containing relatively few minor groups. For example, Group B subdivided on *Monotoca* is such a community, since it persists from Index 155 to Index 20, and embraces only two minor groups as far as the data were analysed.

On this basis four such groups may be distinguished from the complex mosaic of groups of varying validity which comprise the samples studied. These groups, A to D, exist simultaneously over a larger range, 125 to 60, than any other number of groups. Thus within the limitations of the analysis, they are communities approximating societies within the *Eucalyptus baxteri* association. They are identified by 16 indicator species which vary in frequency between groups (Table 1). For example, vegetation containing *Monotoca*, *Persoonia* and *Acacia spinescens*, but not *Pultenaea*, would be either Group A or B. If furthermore it contained *Phyllota*, *Xanthorrhoea* and *Boronia*, but not *Ac. oxycedrus* or *Styphelia*, it would be Group A.

On the other hand, the remaining 64 species analysed are relatively insensitive to the discontinuities that affect the key species. Of these, 22 have a frequency greater than 30% (Table 2), their similar group frequencies indicating their unbiased distribution throughout the area studied. The appearance of the vegetation is dominated by the five species of frequency greater than 75%, *viz.* the tree *E. baxteri*, the small shrubs *L. myrsinoides* and *X. australis*, and the undershrubs *H. sericea* and *L. virgatus*. Superimposed upon this picture of four groups

TABLE 1

INDICATOR SPECIES

Species used to identify the groups; relatively high frequencies are in bold faced type.

Species	Overall	Frequency %			
		A	B	C	D
Monotoca scoparia (Sm.) R.Br.	22	**17**	**100**	0	0
Persoonia juniperina Labill.	8	**17**	**21**	5	0
Acacia spinescens Benth.	2	**10**	**2**	0	0
Pultenaea prostrata Benth. *ex* Hook. f.	9	3	0	**13**	**8**
Phyllota pleurandroides F. v. M.	18	**100**	0	0	0
Xanthorrhoea quadrangulata F. v. M.	6	**32**	0	0	0
Boronia coerulescens F. v. M.	3	**14**	0	1	0
Hibbertia virgata R. Br. *ex* DC. var. *crassifolia* (Benth.) Black	5	**27**	3	0	0
Lhotskya alpestris (Lindl.) Druce	7	**25**	0	2	6
Acacia oxycedrus Sieb. *ex* DC.	2	0	**11**	0	0
Thomasia petalocalyx F. v. M.	15	29	2	15	14
Styphelia adscendens R. Br.	5	0	**16**	2	5
Eucalyptus obliqua L'Herit.	12	8	3	**28**	4
Isopogon ceratophyllus R.Br.	57	77	68	**100**	0
Dodonaea viscosa Jacq.	4	3	0	0	11
Leucopogon collinus (Labill.) R.Br.	23	49	30	22	5

TABLE 2

COMMON SPECIES

Species of overall frequency greater than 30%; frequencies greater than 75% are in bold faced type.

Species	Overall	Frequency %			
		A	B	C	D
MYRTACEAE					
Eucalyptus baxteri (Benth.) Maiden *et* Blakely *ex* Black	**89**	95	97	72	74
Leptospermum myrsinoides Schldl.	**89**	97	98	94	70
Calytrix tetragona Labill. (glabrous form)	30	15	56	28	24
EPACRIDACEAE					
Leucopogon virgatus (Labill.) R.Br.	**80**	61	86	82	84
Astroloma conostephioides (Sond.) F. v. M. *ex* Benth.	74	70	86	70	74
Brachyloma ciliatum Benth.	63	42	70	65	65
Leucopogon ericoides (Sm.) R.Br.	52	19	60	45	79
Epacris impressa Labill.	51	47	40	58	31
Acrotriche serrulata (Labill.) R.Br.	47	32	52	61	39
Astroloma huminisum (Cav.) R.Br.	34	19	13	38	51
A. humifusum var. *denticulatum* (R.Br.) Black	31	34	25	23	44
PROTEACEAE					
Banksia ornata F. v. M. *ex* Meisn.	61	86	65	64	39
Isopogon ceratophyllus R.Br. (see Table 1)	57	x	x	x	x
Banksia marginata Cav. (shrub form)	49	63	57	57	25
Banksia marginata Cav. (tree form)	34	12	32	35	47
LEGUMINOSAE					
Acacia myrtifolia (Sm.) Willd.	30	41	59	26	13
Kennedia prostrata R.Br. *ex* Ait.	30	20	35	36	23
OTHER FAMILIES					
Hibbertia sericea (R.Br. *ex* DC.) Benth.	**84**	80	86	82	85
Xanthorrhoea australis R.Br.	**80**	76	84	93	61
Hibbertia stricta (DC.) F. v. M.	62	83	54	70	40
Hypolaena fastigiata R.Br.	60	78	81	62	35
Tetratheca ciliata Lindl.	48	25	70	55	38
Correa reflexa (Labill.) Vent. var. *reflexa*	40	39	62	49	18

contrasted with common widespread species, are 42 species with similar frequency to that of the indicators, 2 to 29%, but occurring haphazardly in the groups and thus distributed unpredictably throughout the vegetation. Superficially, then, the dry sclerophyll forest studied appears to comprise an open tree canopy over a layer of small shrubs dominated by relatively few species. The overall impression is of uniformity. However measurement reveals that, of the numerous low frequency species, some consistently associate in societies or groups.

Since it is difficult to assess the validity of the groups other than by field experience, it is necessary to state at least some sources of error inherent in the methods used. Firstly, there are the basic errors due to a sampling intensity of about 0·001%, and to operator fallibility in naming and scoring species. Secondly, data based on frequency are liable to misrepresentation because quadrat size affects the results. For example, a large quadrat overemphasizes uncommon species, whilst a small quadrat underemphasizes the importance of species of patchy distribution. This defect can be overcome only with additional data on variables such as density. Thirdly, the analytical method was arbitrarily selected from several which might have been used (Welbourn and Lange, 1967). Its most serious fault is that in subdividing on a single association index, this method does not indicate the extent or nature of any subordinate association which may exist. That is, there is no indication of the overall confidence with which a particular subdivision is made. Furthermore the association index itself falls short of theoretical excellence. Finally, it should be recognized that any such method imposes definite cut-off points to groups between which there is some continuity. Nevertheless such groups provide at least an objective basis upon which to classify and map vegetation variation.

Fig. 3 is such a map which reveals that the groups themselves are more or less geographically restricted. For example, Group A tends to the north-central area, B to the south-east, C to the west and south, and D to the east and north. Since these appear not to be chance distributions, there are likely to be environmental factors correlated with them. Several factors will be discussed, to illustrate the sort of hypothesis which may arise from such vegetation mapping.

If time was the only factor involved, some groups could be expected to represent stages in a succession, and so to predominate on ranges of similar age. Such trends are apparent; for example, between Naracoorte and Robe, Group D is gradually replaced firstly by A and B, then by C on the younger ranges. However, this evidence rests on the assumption that all other environmental factors are held constant. This was not so in the case of soil and topography which were more variable than expected. Thus the correlation of vegetation with habitat age cannot be tested under the sampling conditions of this study. Similar remarks apply to a correlation with aspects of climate such as coastal influence and annual rainfall.

From field descriptions of the sampling areas, it is apparent that variations in soil and topography are correlated to some degree with vegetation variations. For example Group A occurs on sand ridges normal to the ranges, suggesting an immature profile; the *Eucalyptus baxteri* here is stunted, and *E. diversifolia* Bonpl. was observed nearby suggesting a gradation to the solodized solonetz soil common to the north. Group B occurs on deep sands in the higher rainfall area; the vegetation is profuse and undisturbed. Group C is a diversified group which tends to occur in flat, shallow areas, particularly to westward where the ranges appear to have less siliceous sand covering the limestone. The next subdivision of this group (Fig. 2) is on *E. obliqua*, a species known to occur on shallower soils. Group D occurs on the eastern sides of ranges well away from limestone, but with some seasonal watertable influence.

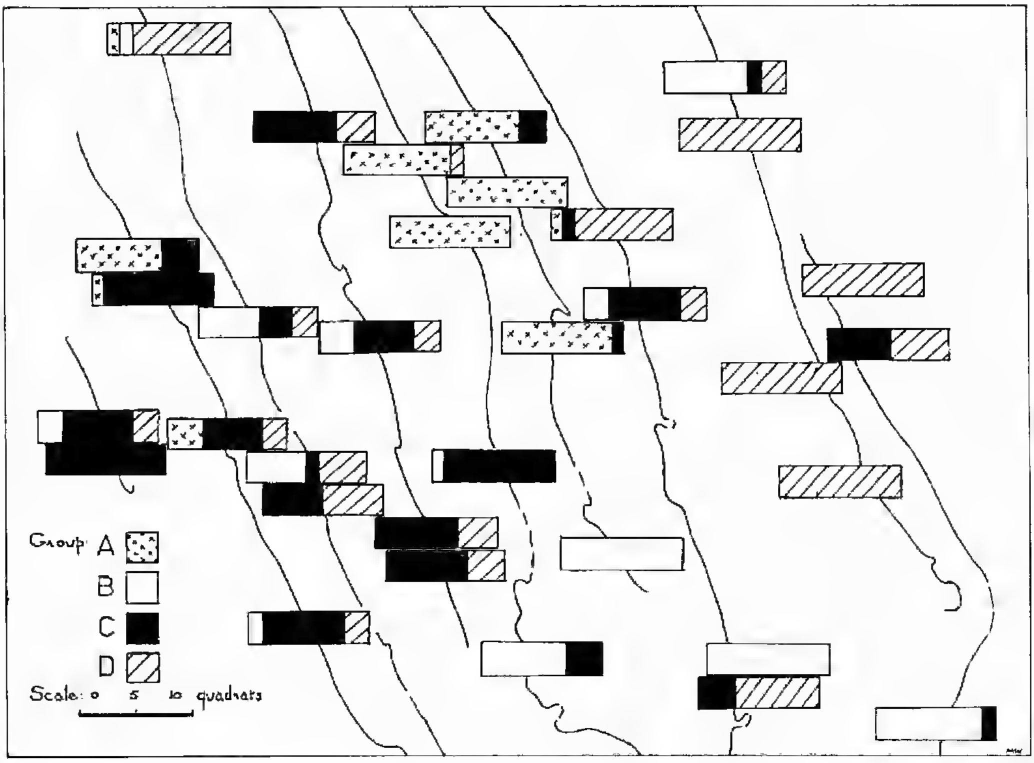

Fig. 3.

Clearly, profile measurements and more intensive sampling are required to substantiate any correlation of vegetation with soil and topography. Such correlation, once established, will be of value in habitat classification and mapping.

REFERENCES

BLACKBURN, G., BOND, R. D. and CLARKE, A. L. P., 1965. Soil development associated with stranded beach ridges in South-East South Australia. C.S.I.R.O. Aust. Soil. Publ. No. 22.

CROCKER, R. L., 1944. Soil and vegetation relationships in the Lower South-East of South Australia. A study in ecology. Trans. R. Soc. S. Aust., 68, pp. 144-172.

SPRIGG, R. C., 1952. The geology of the South-East Province, South Australia, with special reference to Quaternary coastline migrations and modern beach developments. Geol. Surv. S. Aust. Bull. No. 29.

WELBOURN, R. M. E. and LANGE, R. T., 1967. Subdividing vegetation on inter-specific association. Vegetatio Acta Geobotanica, 15, pp. 129-136.

WILLIAMS, W. T. and LAMBERT, J. M., 1959. Multivariate methods in plant ecology. I. Association-analysis in plant communities. J. Ecol., 47, pp. 83-101.

Plate 1

General view of the area studied, looking eastward towards Naracoorte. Three ranges, each partly cleared of natural vegetation, are emphasized in the foreground and middle distance with a line along their crests.